SIEMENS ZAHLER FABRIK
NURNBERG AREA

COMBINED INTELLIGENCE OBJECTIVES
SUB-COMMITTEE

SECRET

REPORT ON VISIT TO SIEMENS ZAHLER FABRIK IN THE NURNBERG AREA

Reported by:

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CIOS Target Numbers 1/467 & 27/205
Radar Instruments and Equipment

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Contents of Report

Investigators - Sqn. Idr. G.C. Barker — Ministry of Aircraft Production.

Capt. Robson — Ministry of Supply.

SECTION A - LOCATION OF DEVELOPMENT LABORATORIES

Schloss Neuhaus, Neuhaus bei Hochstadt.

SECTION B - PURPOSE OF VISIT

To interrogate Dr. Edler in connection with small D.C. Motors suitable for use in servo mechanisms. This took place on 7th to 8th June, 1945.

SECTION C - GENERAL RESULTS OF VISIT

Development work had been carried out on D.C. Motors with very high accelerations due to extremely low inertia armatures consisting of windings in the form of a hollow cup. The work had been very successful, several types of motors being developed with locked accelerations of the order of 200,000 r.p.m./sec. in sizes up to 100 watt mechanical output.

SECTION D - NARRATIVE

The Laboratories were located in a small castle in Neuhaus having been evacuated there from Nürmberg after the latter town had been severely bombed. A small group of workers lived and worked there under the direction of Dr. Edler. Only development work was undertaken with construction limited to samples.

Work on these special D.C. Motors was started in 1940 and was originally carried out in connection with integrating mechanisms for computing and differential analyzers. A small motor was required to have a very linear speed/voltage characteristic with a very short time constant take up so that fairly rapid fluctuating voltages could be converted into speeds. This original motor was called an I Motor (I for integration) or Messmotor and as far as is known it was the first attempt to make a commercial motor without any iron core in the armature (see Fig. 1). The aramture consists of a hollow cored winding in the form of a cup with a small 3 segment commutator attached (see Fig. 2). This fits into a specially designed field magnet being located by two small stone bearings.

The motors had been in production for about four years, about 20,000 having been made in the Nürmberg factory, the earlier types with Alni 120 magnets but the later ones with the Superior Alni400 magnets. With this latter magnet the initial acceleration is of the order of 200,000 r.p.m./sec. Full details of inertia etc. can be seen from the data sheets at the end of this report.

In 1944 Dr. Edler was asked to produce some larger power machines for use in Servomechanisms. Details of these are as follows:-

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SECTION E - 10 WATT MOTOR (FIG. 3)

This motor was of similar construction to the I Motor except that the Alnn 400 magnet was fixed inside the hollow armature core with an outer core to close the magnetic path. Ball bearings were used in place of stone bearings due to the increased size of the machine. The time constant of this machine was of the order of 10millisecs - in general it was a larger version of the I Motor and had an equivalent acceleration and high performance. The development of this motor was complete and production had started in Nürmberg in various voltage ratings.

SECTION F - 100 WATT MOTOR (FIGS. 4 and 5)

This motor was still under development and was not in production. The armature was of the same cup form as the other motors described but was very much more robust and more carefully constructed. Field flux was obtained by a normal wound system in place of a permanent magnet - due to the increased air gap the power dissipated in the field system - was quite high (approx. 70 watts) so that the motor runs quite hot. Bearings and mechanical construction had been designed to enable the motor to run at 12000 r.p.m. and produce about 900 gm cm. at this speed continuously. The time constant had been kept down to about 8 m/sec. - other details being as follows:-

Moment of Inertia of Armature	3.4 microsec. ft^2
Torque available at 1200 r.p.m.	900 gm. cm.
Mechanical power at this speed	109 watts
Equivalent acceleration on constant current basis	290,000 r.p.m./sec.
Equivalent locked acceleration if run from Amplidyne	300,000 r.p.m./sec.
Armature nominal voltage	27 volts D.C.
Load Current (armature only)	5.3 amps D.C.
Armature resistance	0.7 ohms
Field voltage	27 volts D.C.
Field resistance	10 ohms

As the motor is built at the moment the overheating problem is serious and if the machine is locked with full armature voltage applied it will obviously burn out very quickly. It is proposed to build the removed sample into a servo system using a form of metadyne control to safeguard the machine with metadyne compensation adjusted to limit the current to a safe value. It is then proposed to rewind the fields of the machine into a split field form running the armature with a constant current of about 5 amps and forced air cooling.

With a little further development in the form of reshaping the body to enable forced air cooling to be applied as in the A.C. type of cup motors it is believed that this type of motor will represent a valuable addition to the types of servomotors available.

SECTION G - TACHOGENERATOR (FIGS. 6 AND 7)

A small tachogenerator had been developed in 1940 using the cup form of armature. The Alnipermanent magnet was fixed inside the armature with a closed iron frame external. Due to lack of iron in the armature Dr. Edler claimed that the ripple was only about 1% of the D.C. voltage output. As originally designed they were intended for measuring small differences in speed for a speed control system. Their construction makes them ideal for servo system D.C. feedback generators due to their very small inertia and the very pure and linear voltage output.

SECTION H - DATA FOR I MOTORS.

Data for all models using Alni magnets	
No load speed at rated voltage U_N	2000 r.p.m. $\pm$1%
Variation of free running speed by temperature alteration between -40 and +70°C.	
Without Compensation (Series Immb .....)	About 0.35% per 10°C.
With Compensation (Series IMMb .....k)	About $\pm$0.1% per 10°C.
Ratio of speeds between ticking over and upper limit (3 x U_N)	
Free running	About 1:1000
With 1 gcm load	About 1:100
Time constant	About 9.5 m.sec.
Suitable for temperature range	-60 to +70°C.
Rated max. accelerations axial:	Up to 1500 m.sec.^{2}
radial:	Up to 500 m.sec.^{2}
Without shape distortion:	Up to 4000 m.sec.^{2}
Life at U_N and no load	About 500 hours
At higher powers correspondingly less.	
Electrical finish	Soldering
Mechanical finish	Stone bearings capable of taking a 9:1 overload
Weight of the motor	About 300 gm.
Weight of the armature	About 4.2 gm.
Moment of Inertia of Armature	See page 2.

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Without Temperature Compensation	Model		Lmma 1,5	Lmma 3	Lmma 6	Lmma 12	Lmma 16	Lmma 24
	Apparatus No. ZrC		96 90 900	96 90 901	96 90 902	96 90 903	96 90 904	96 90 905
	Official App. No.		152D4601A-1	152D4602A-1	152D4603A-1	152D4604A-1	152D4605A-1	152D4606A-1
With Temperature Compensation	Model		LMMa 1,5k	LMMa 3k	Lmma 6k	Lmma 12k	LMMa 16k	Lmma 24k
	Apparatus No. ZrC		96 90 920	96 90 921	96 90 922	96 90 923	96 90 924	96 90 925
	Official App. No.		152D4601B-1	152D4602B-1	152D4603B-1	152D4604B-1	152D4605B-1	152D4606B-1
Nominal Voltage		V	1,5	3	6	12	16	24
Upper Voltage Limit		V			3 x U_N			
Armature Resistance at Standstill		Ohm	2,8	10	40	220	370	840
Stalled Torque at U_N		gcm	36	40	40	29	31	30
Loss of Speed per gcm load		rpm	55	50	50	69	65	66
Stalled Current at U_N and standstill		mA	535	300	150	54,5	43	28,5
Starting Voltage for unloaded motor		mV	4,5	7,5	15	40	50	80
Increase of starting voltage per gcm load		mV	42	75	150	415	520	800
Starting Current for Unloaded Motor		mA	1,6	0,75	0,38	0,18	0,14	0,10

Without Temperature Compensation	Model		Imma 1,5	Imma 3	Imma 6	Imma 12	Imma 16	Imma 24
	Apparatus No. ZrC		96 90 900	96 90 901	96 90 902	96 90 903	96 90 904	96 90 905
	Official App. No.		152D4601A-1	152D4602A-1	152D4603A-1	152D4604A-1	152D4605A-1	152D4606A-1
With Temperature Compensation	Model		Imma 1,5k	Imma 3k	Imma 6k	Imma 12k	Imma 16k	Imma 24k
	Apparatus No. ZrC		96 90 920	96 90 921	96 90 922	96 90 923	96 90 924	96 90 925
	Official App. No.		152D4601B-1	152D4602B-1	152D4603B-1	152D4604B-1	152D4605B-1	152D4606B-1
Increase of starting voltage per gcm load		mA	15	7,5	3,75	1,88	1,4	0,95
Free running current at U_N		mA	4,8	2,4	1,2	0,6	0,45	0,30
Upper limit of Current at U_N *			30	24	20	15	13,5	12
Useful Torque at U_N *		gcm	1,7	2,88	5,0	7,66	9,43	12,3
Useful power at U_N		watt	0,033	0,055	0,089	0,115	0,134	0,148
Speed under load		rpm	1900	1860	1750	1470	1390	1180
Starting power (U_N X Starting Current)		watt	0,8	0,9	0,9	0,65	0,69	0,686
Moment of Inertia of Armature		gcm^2	0,00162	0,0018	0,0018	0,0013	0,0014	0,00135

* Exceeding these upper limits is permissible for a short duration but it shortens the life of the Commutator, brushes and bearings.

Technical Data for I Motors from Siemens-Schuckertwerke AG,
Drawing No. ZrCR9690910

Data for all models using Alni 120 Magnets:	
No load speed at rated voltage U_N:	4000 r.p.m. $\pm$1%
Variation of free running speed by temperature alteration between -40 and +70°C	
Without Compensation (Series LMMb .....)	About 0.35% per 10°C
With Compensation (Series LMMb .....)	About $\pm$0.1% per 10°C
Ratio of speeds between ticking over and upper limit ($3XU_N$)	
Free running	About 1:250
With 1 gcm load	About 1:50
Time Constant	About 38 m.sec.
Suitable for temperature range	-60 to +70°C
Rated max. accelerations axial:	Up to 1500/m.sec^2
radial:	Up to 500/m.sec^2
Without shape distortion:	Up to 4000/m.sec^2
Life at U_N and no load	About 500 hours
At higher powers correspondingly less.	
Electrical finish	Soldering
Mechanical finish	Stone bearings capable of taking a 9:1 overload
Weight of the Motor	About 300 gm.
Weight of the Armature	About 4.2 gm.
Moment of Inertia of Armature	See page 2

Without Temperature Compensation	Model	IMMb 1,5	IMMb 3	IMMb 6	IMMb 12	IMMb 16	IMMb 24
	Apparatus No. ZrC	96 90 910	96 90 911	96 90 912	96 90 913	96 90 914	96 90 915
	Official App. No.	152D4601C-1	152D4602C-1	152D4603C-1	152D4604C-1	152D4605C-1	152D4606C-1
With Temperature Compensation	Model	IMMb 1,5k	IMMb 3k	IMMb 6k	IMMb 12k	IMMb 16k	IMMb 24k
	Apparatus No. ZrC	96 90 930	96 90 931	96 90 932	96 90 933	96 90 934	96 90 935
	Official App. No.	152D4601D-1	152D4602D-1	152D4603D-1	152D4604D-1	152D4605D-1	152D4606D-1
Nominal Voltage	V	1,5	3	6	12	16	24
Upper Voltage Limit	V			3 x U_N			
Armature Resistance at Standstill	Ohm	2,8	10	40	220	370	840
Stalled Torque at U_N	gcm	18	20	20	14,5	15,5	15
Loss of Speed per gcm load	rpm	220	200	200	276	260	264
Stalled Current at U_N and Standstill	mA	535	300	150	54,5	43	28,5
Starting Voltage for Unloaded Motor	mV	18	30	60	160	200	320
Increase of starting voltage per gcm load	mV	84	150	300	830	1040	1600
Starting Current for Unloaded Motor	mA	6,5	3	1,5	0,75	0,60	0,40
Increase of Starting Current per gcm load	mA	30	15	7,5	3,75	2,8	1,9

With / Without Temperature Compensation	Model	LMMb 1,5	LMMb 3	LMMb 6	LMMb 12	LMMb 16	LMMb 24
	Apparatus No. ZrC	96 90 910	96 90 911	96 90 912	96 90 913	96 90 914	96 90 915
	Official App. No.	152D4601C-1	152D4602C-1	152D4603C-1	152D4604C-1	152D4605C-1	152D4606C-1
	Model	LMMb 1,5k	LMMb 3k	LMMb 6k	LMMb 12k	LMMb 16k	LMMb 24k
	Apparatus No. ZrC	96 90 930	96 90 931	96 90 932	96 90 933	96 90 934	96 90 935
	Official App. No.	152D4601D-1	152D4602D-1	152D4603D-1	152D4604D-1	152D4605D-1	152D4606D-1
Free running Current at U_N	mA	9,6	4,8	2,4	1,2	0,9	0,6
Upper limit of Current at U_N *	mA	30	24	20	15	13,5	12
Useful Torque at U_N *	gcm	0,7	1,28	2,34	3,68	4,54	6,0
Useful Power at U_N *	watt	0,028	0,049	0,085	0,114	0,132	0,147
Speed under Load	rpm	3840	3740	3530	2960	2810	2380
Starting Power (= U_N x Starting Current)	watt	0,8	0,9	0,9	0,65	0,69	0,686
Moment of Inertia of Armature	gcm^2	0,00162	0,0018	0,0018	0,0013	0,0014	0,00135

* Exceeding these upper limits is permissible for a short duration but it shortens the life of the Commutator, brushes and bearings.

Technical Data for I Motors from Siemens-Schuckertwerke AG,
Drawing No. ZrCR9690910

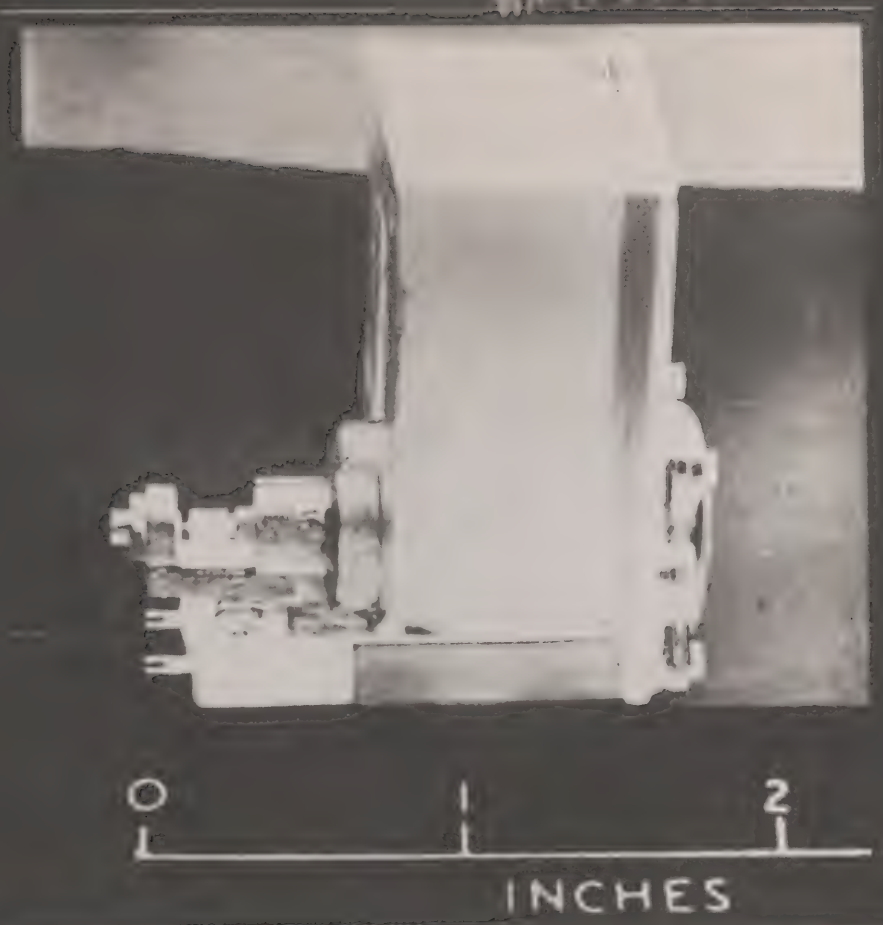

FIG. 1. I MOTOR.

FIG. 2.
ARMATURE OF I MOTOR.

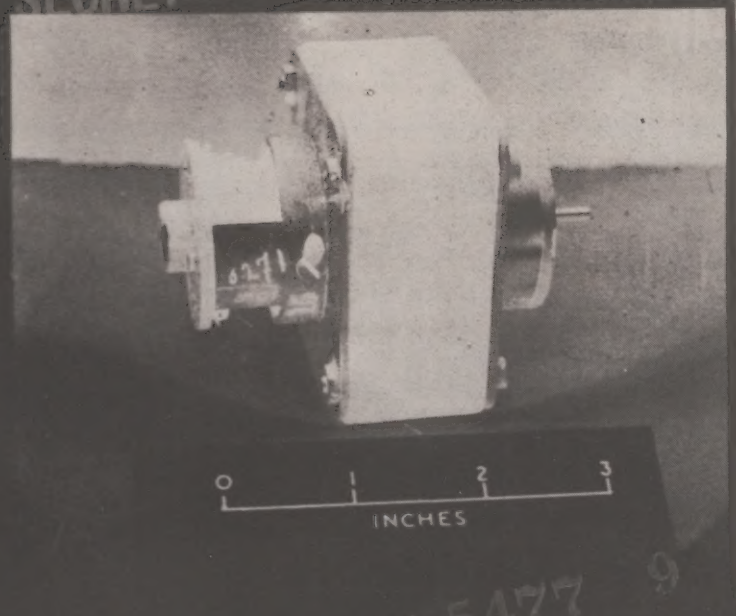

FIG. 3.
10 WATT
MOTOR.

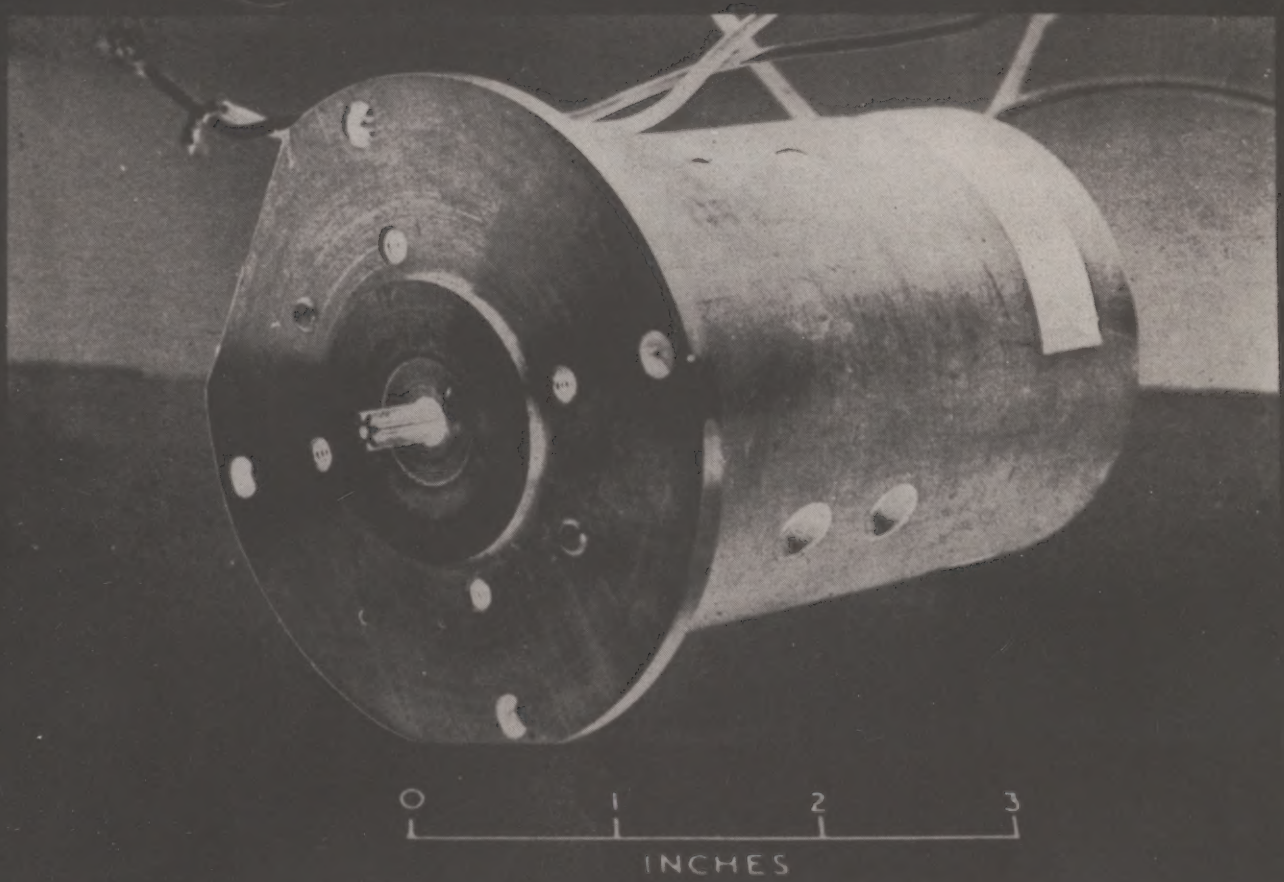

FIG. 4. 100 WATT MOTOR.

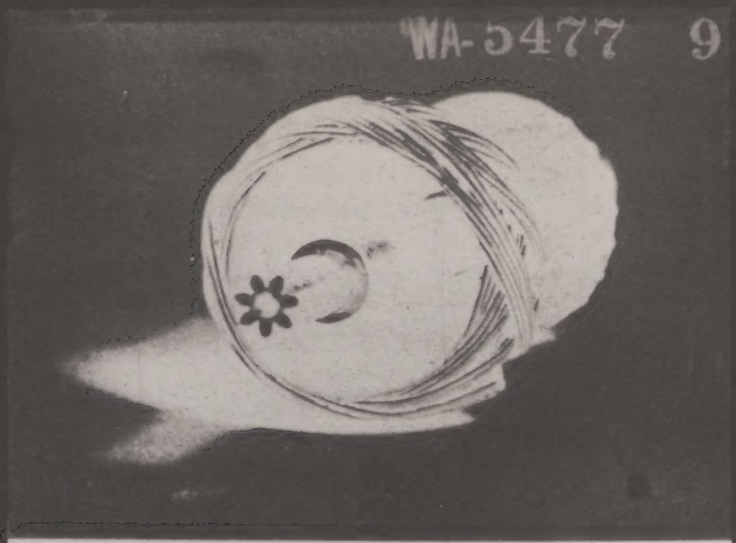

FIG. 5. ARMATURE OF 100 WATT MOTOR.

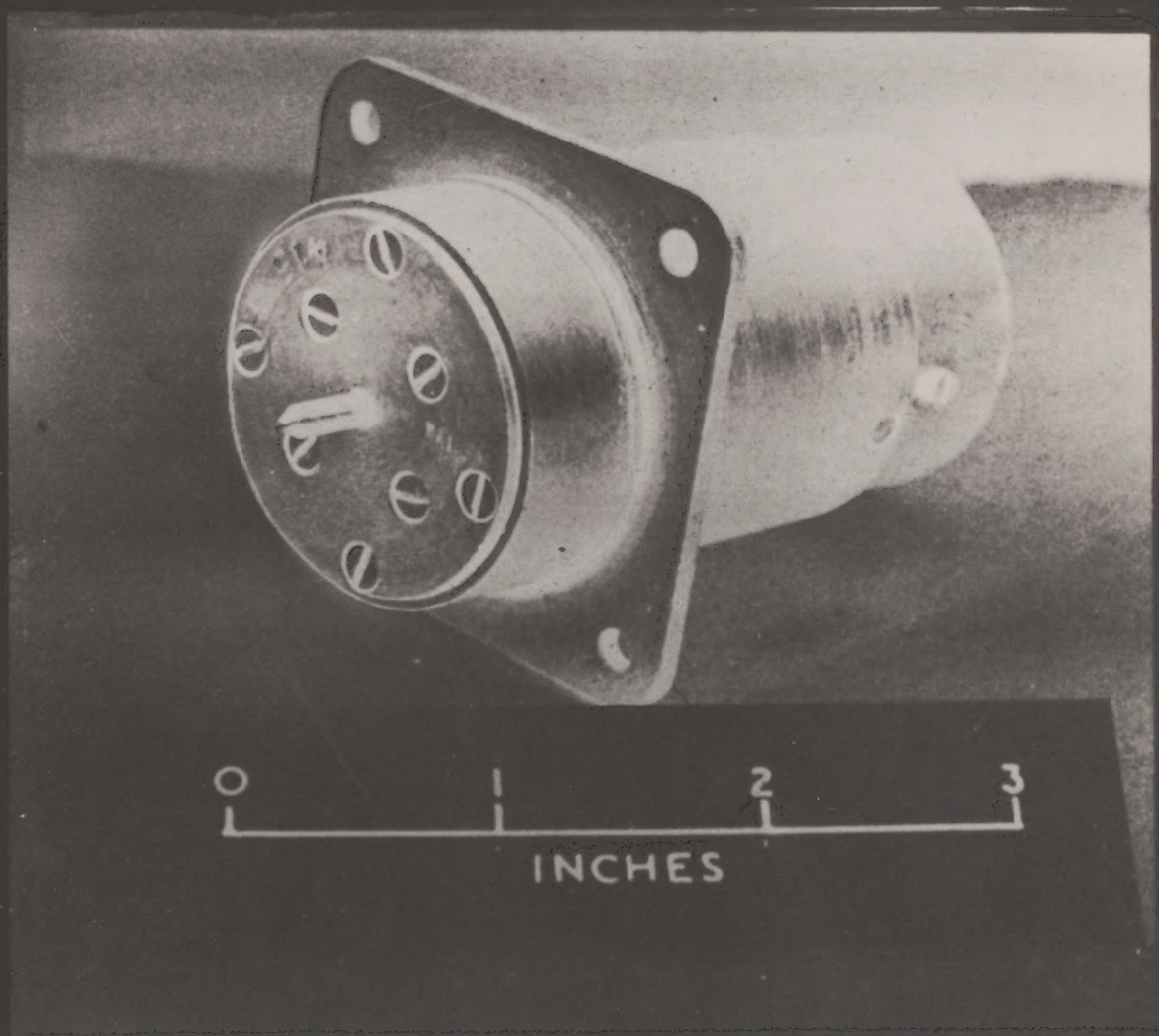

FIG. 6. TACHO GENERATOR.

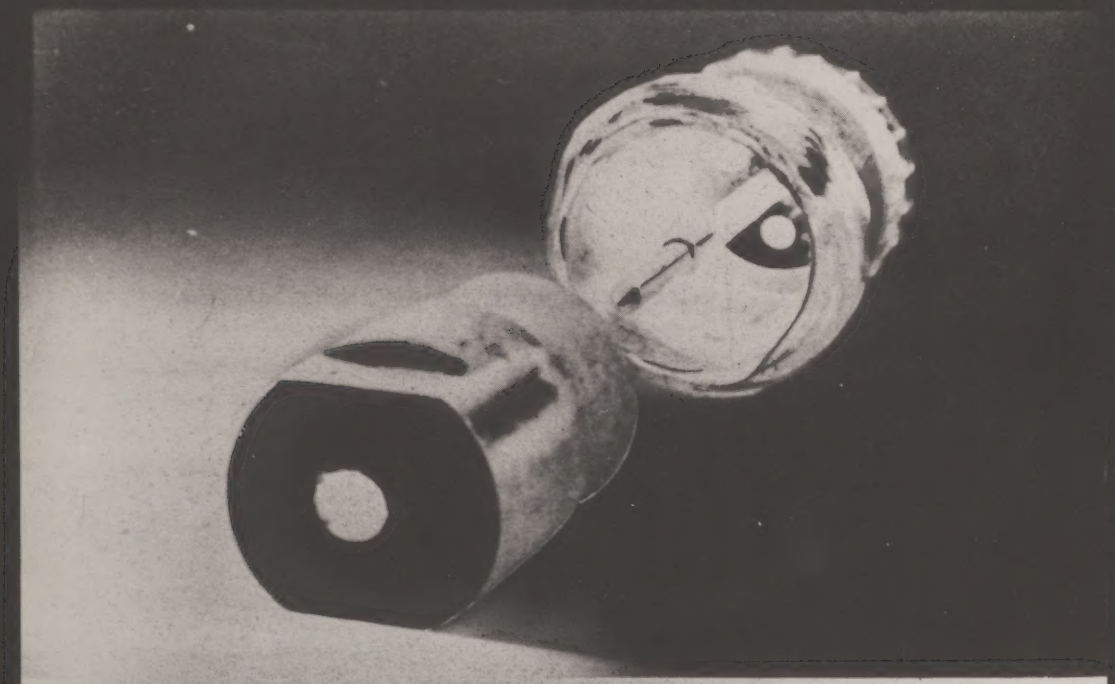

FIG. 7. ARMATURE OF TACHO GENERATOR SHOWING HOW MAGNET FITS INSIDE.

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